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ABSTRACT

The author contends that model misspecification can occur even after researchers have selected the generally most appropriate class of methods, or general linear model techniques. It is suggested specifically that canonical correlation analysis may provide more meaningful results, as compared with regression, particularly if analysis is augmented by the computation of structure coefficients. It is also suggested that contemporary analytic practice reflects some improvements over more traditional practice. Researchers are increasingly investigating multivariate problems with multivariate methods. Greater use of the multivariate general linear model, or canonical correlation analysis, augmented by the calculation of appropriate coefficients, including structure coefficients, is proposed for future research. (DWH)

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MODEL MISSPECIFICATION ERROR IN CORRELATIONAL STUDIES

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ABSTRACT

The purpose of this paper is to argue that model misspecification can occur even once researchers have selected the generally most appropriate class of methods, i.e., general linear model techniques. More specifically, it is suggested that canonical correlation analysis may provide more meaningful results than other general linear model techniques, particularly if analysis is augmented by the computation of structure coefficients. Several trends in recent methodological practice are discussed.

For the past several decades social scientists have periodically reviewed typical analytic practice with a view toward improving methodology. For example, Cohen (1968) suggested that some researchers use analysis of variance techniques when general linear model techniques would be more appropriate; Thompson (1981) comments on a possible etiology for and some consequences of this situation. Clark (1973) suggested that research might be more profitable if more researchers employed "random" and "mixed" effects models; Willson (1982) suggests that this form of "model misspecification" continues today. Marascuilo and Levin (1976) have cautioned against the dangers of Type IV errors, i.e., the incorrect interpretation of a correctly rejected hypothesis; they suggested that these errors may be particularly likely when interaction effects and post hoc tests are interpreted. Thus, the literature suggests that model misspecification, in its general sense, occurs at various levels, including the selection of class of analytic technique, the selection of error terms with which to test omnibus effects, and the testing of post hoc comparisons.

The purpose of this article is to demonstrate that model misspecification can occur even once researchers have selected the generally most appropriate class of methods, i.e., general linear model techniques. More specifically, it is suggested that canonical correlation analysis may provide more

meaningful results, as compared with regression, even when the research context is held constant. Thompson (1982b) provides a review of canonical methods; a computer program which implements some recent extensions of canonical methods is also available (Thompson, 1982a).

Heuristic Example

Table 1 presents hypothetical data which can be used to make the discussion more concrete. The hypothetical case involves three predictor variables: pupil self-concept, income of the pupils' families, and the per-pupil expenditure of the pupils' schools. The researcher has two options with respect to selection of criterion variables. Composite achievement scores are available, or the researcher can consider both the reading and the math achievement subtest scores.

INSERT TABLE 1 ABOUT HERE.

Even though the hypothetical study did not involve any experimental manipulation, some researchers confuse design-choice consequences with analytic-choice consequences, and might dichotomize or trichotomize the three predictor variables and perform ANOVA or MANOVA analyses. Presume, however, that the researcher did not elect to distort the reality that the data are supposed to represent; this can occur when normally-distributed, intervally-scaled variables

are converted to uniformlly-distributed, nominally-scaled variables simply in order to perform OVA techniques. Happily, the hypothetical researcher has selected a general linear model framework for the analysis.

Three analytic options then become available. First, the researcher might perform a multiple regression analysis employing composite test scores as the sole criterion variable. Second, the researcher might perform two multiple regression analyses employing the reading and math subtest scores as separate criterion variables in the two analyses. Or, finally, the researcher might perform a canonical correlation analysis which simultaneously considers both the two subtest criterion variables and the three predictor variables. The results associated with these three options are all presented in Table 2.

INSERT TABLE 2 ABOUT HERE.

The Table 2 results make clear that analytic choices can have noteworthy impacts on interpretation, even when the choices all fall within the same analytic framework, and even when the various criterion variables are substantially correlated with each other. For example, the equation "weights" and structure coefficients for the pupil expenditure variable tend to differ across the solutions. The estimates of the predictive effectiveness of the equations also tend to

fluctuate somewhat across solutions. This raises questions regarding the appropriate analytic choices in such situations. The answers to these questions may have implications for decisions in other situations as well.

As a general rule, researchers should employ more rather than fewer criterion variables in their studies. In education, most variables have both multiple causes and multiple effects. Researchers should employ analytic techniques which honor the complex nature of the reality to which the researcher is attempting to generalize. As Kerlinger (1973, p. 149) argues, "to account for the complex psychological and sociological phenomena of education requires design and analytic tools that are capable of handling the complexity, which manifests itself above all in multiplicity of independent and dependent variables."

Thus, in cases like the hypothetical situation presented here, the use of the two subtest achievement scores would have been preferable to the use of the single composite score variable. The only empirical case for the use of composite rather than subtest scores is that composite scores tend to be more reliable than their component subtest scores. On the basis of superficial thought, some researchers seem to believe that "longer" tests are always more reliable than "shorter" tests, as a function of some mysterious effects of test length

per se. Actually, test length affects reliability only insofar as length may affect variability, which is usually the most direct determinant of reliability (see Gronlund, 1976, p. 119, for a readable explanation). In any case, it is also important to remember that improvements in reliability which are derived by increasing the number of test items can also paradoxically result in decreased test validity.

Given that multiple criterion variables are generally of interest to researchers, it can be argued that canonical methods frequently provide important analytic benefits. For example, the calculation of separate correlational analyses for multiple criterion variables usually inflates the probability of making Type I errors, depending on the degree of correlation among the criterion variables. Futhermore, such approaches distort reality to the extent that ignoring relationships among the criterion variables can also distort the substantive interpretation of results, as noted in the heuristic example; this distortion is almost as unfortuante as the Procrustean application of OVA techniques in non-experimental studies (Thompson, 1981).

Incidentally, the Table 2 results also provide an opportunity to comment of the common but unfortunate failure to calculate structure coefficients in correlational research. For example, few researchers report structure coefficients

when multiple regression techniques are applied, even though:

> one of the most useful ways to look at the regression function is in terms of its correlations with the predictor elements on which it is defined.... Our tendency to deemphasize the b[eta] weights stems from experience with the phenomenon of extreme fluctuation of regression weights from sample to sample when the sample size is small. Even when the sample size is moderate there is substantial fluctuation (Cooley & Lohnes, 1971, pp. 54-55).

Levine (1977, p. 20, his emphasis) is equally adamant about the importance of structure coefficients in the canonical case: "I specifically say that one has to do this [interpret structure coefficients] since I firmly believe as long as one wants information about the nature of the canonical correlation relationship, not merely the computation of the [canonical function] scores, one must have the structure matrix."

In summary, it has been suggested that contemporary analytic practice reflects some improvements over more traditional practice. For example, researchers are increasingly investigating multivariate problems with multivariate methods. There have also been some improvements with respect to the historically excessive use of OVA techniques. Hopefully, the future will bring more use of the multivariate general linear model, i.e., canonical correlation analysis, augmented by the calculation of appropriate coefficients, including structure coefficients.

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Table 1

Hypothetical Correlation Matrix

Variable	X	Y	Z	A	B	C
Composite Achievement (X)	--					
Reading Achievement (Y)	.7	--				
Math Achievement (Z)	.8	.6	--			
Self-Concept (A)	.4	.4	.2	--		
Family Income (B)	.5	.3	.2	.5	--	
Pupil Expenditure (C)	.1	.3	.1	.0	.4	--

Table 2
Associated Results

	Criterion/Solutions						Canonical Results			
	X		Y		Z		I		II	
Variable	BW	SC	BW	SC	BW	SC	FC	SC	FC	SC
Reading Achievement (Y)							1.14	.98	-.51	.22
Math Achievement (Z)							-.27	.41	1.22	.91
Self-Concept (A)	.18	.75	.42	.80	.15	.83	.85	.78	-.27	.32
Family Income (B)	.44	.94	-.03	.60	.10	.83	-.13	.56	1.18	.75
Pupil Expenditure (C)	-.07	.19	.31	.60	.06	.42	.67	.61	-.74	-.27
R or Rc	.53		.50		.24		.51		.12	

Note: "BW" = beta weights; "SC" = structure coefficients; "FC" = function coefficients.